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A STUDY OF THE DIGESTIVE POWER OF SARRACENIA PURPUREA

By Winifred J. Robinson

Introduction

The family Sarraceniaceae consists of three genera, two of which are each represented by a single species, *Heliamphora*, collected in Guiana by Schomburgk and Im Thurm, and *Darlingtonia*, which grows in the mountains of California, while *Sarracenia* has seven species described for eastern North America (Macfarlane, in Engler, Pflanzenreich (Heft 34) 4^{110}: 24. 1908). Natural hybrids have been observed by Harper (Bull. Torrey Club **30**: 332. 1903; **33**: 236. 1906) and Macfarlane (*l. c.* 21) and numerous artificial hybrids have been produced by horticulturalists. All members of the family are native to sunny bogs where their pitchered leaves appear in rosettes from the center of which the flowers arise.

The leaves of *Sarracenia purpurea* are trumpet-shaped with a ventral wing and a terminal lid or lamina (FIG. 1*a*). The outer surface has short, blunt, upwardly directed hairs, cells with the wavy outline of ordinary epidermal cells, and numerous stomata. The inner surface of the terminal portion, or lamina, the "attractive surface" according to Hooker (Nature **10**: 369. 1874) is covered with stiff, reflexed, whitish hairs, the surface of which is corrugated. These contained, in the specimens examined by the writer, a colorless or pinkish fluid with vacuoles, though Vogt (Sitzungsb. Akad. Wiss. Wien **50**: 281. 1864) stated that he found no solid or liquid contents in them but that they were filled with air, and Wunschmann (E. & P. Nat. Pflanzenfam. 3^2: 352. 1891) speaks of them as filled with air. At the entrance to the

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pitcher cavity the hairs cease and a smooth area succeeds, due to the somewhat papillate form of the epidermal cells, which was termed by Hooker the "conducting zone" (FIG. 1*b*). The walls are strongly cuticularized, especially in the rolling margin between the inner and outer surfaces of the pitcher. Below this is a glabrous area, the "glandular zone" (FIG. 1*c*), and at the base of the pitcher is a region which bears long needle-like hairs, the "detentive surface" (FIG. 1*d*). Each of these areas bears glands except the last. Hooker (*l. c.*) stated that there were no honey-glands in *Sarracenia purpurea*, but Schimper (Bot. Zeit. **40**: 227. 1882) thought from the structure of crystals in the upper part of the leaves which he had dried, as well as from the behavior of insects, that nectar glands occurred in the upper part of the pitcher. Goebel (Pflanzenbiol. Schild. **2**: 90. 1891) also described nectar glands in this area. The discrepancy between these two statements may be explained by the theory which Hooker (*l. c.*) has advanced for other species, that "the saccharine fluid only makes its appearance during one particular period in the life of the pitcher." Macfarlane (Ann. Bot. **7**: 407. 1893) says that the protective winter bud-leaves show many honey-glands particularly on the outer surface.

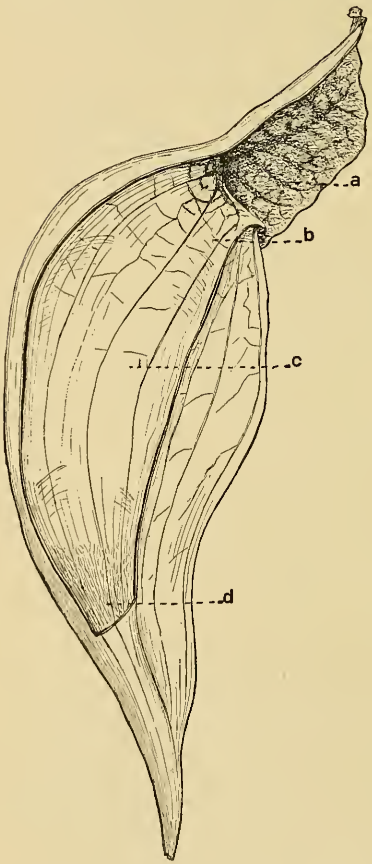

FIG. 1. Leaf of *Sarracenia purpurea* with a portion of the pitcher cut away to show the areas described by Hooker as (*a*) the "attractive surface," (*b*) "conducting zone," (*c*) "glandular -zone," and (*d*) "detentive surface."

St. Hilaire (Morphol. Vég. 142. 1840) and Duchartre (Élém. Bot. 308. 1867) regarded the leaf as a pitchered petiole with a lid which represents the true leaf. Baillon (Compt. Rend. **71**: 639. 1870) compared it to a peltate Nelumbian leaf and interpreted the lower part as the petiole, the pitcher with its wing as corresponding to a ridge on the outer base of peltate leaves of certain Nymphaeaceae, while the lid represents a terminal lobe. Asa Gray described the pitcher as a phyllodium, the terminal lid as the blade of the leaf. Macfarlane (Ann. Bot. **3**: 264. 1889) describes it as the hollowed-out upper part of the midrib "in front of which two elongated green leaflets have fused, producing a prominent wing, a dorsal continuation of the pitchered midrib in flattened form which gives off on either side two leaflets, the whole constituting the lid." He bases this theory largely upon the arrangement of the vascular bundles, which are in two parallel rows with their xylem portions facing each other. Goebel (*l. c.* **2**: 76. 1891) criticizes this view, saying that the primordium of the leaf resembles that of bud-scales with no differentiation into petiole and blade. He regards the lid and pitcher both as parts of the structure termed lamina in the ordinary type of leaf. Bower (Ann. Bot. **4**: 167. 1889) has reviewed the theories of Macfarlane and Goebel and concluded that "the leaf of *Sarracenia* is a simple phyllopodium, consisting of (1) a basal sheathing portion, (2) a middle portion which may be hollowed by involution of the upper surface, and bear upon its upper surface a phyllodineous flap, and (3) the lid which is the simple, flattened termination of the leaf."

The leaves of seedlings, with the exception of the cotyledons, develop as pitchers in all the species that have been examined. Shreve (Bot. Gaz. **42**: 118. 1906) describes the development of seedling leaves of *S. purpurea* as follows: "The first epicotyledonary leaf arises opposite the interval between the cotyledons. It is finger-shaped with a somewhat broadened base. On reaching a length about twice its diameter there begins a rapid lateral outgrowth of the tissue of an O-shaped area on the side of the leaf rudiment which faces the growing point, giving rise to a pit which is destined to become the cavity of the pitchered leaf.

The basal part of the O-shaped outgrowth now begins to grow upward, in which it is accompanied at the same rate by the upper portion of the O, which at the same time carries forward the apical growth of the leaf. The cavity of the pitcher thus grows in depth by the upward growth of the tissue by which it is surrounded. The bottom of the cavity is subsequently elevated by the further growth of the tissue beneath it."

Plants of *S. purpurea* kept under glass for a year at the New York Botanical Garden showed a marked tendency to form blade-like structures instead of ascidial leaves. Goebel (*l. c.* 73) describes in several species this tendency to produce leaves without pitchers at the close of the vegetative period.

The peculiar form of the leaves of *Sarracenia* has attracted the attention of the curious ever since their discovery. A specimen of *S. flava* brought to France by a sailor with the legend that it grew on a fragrant Canadian tree was named leaf of the incense tree (*Thuris Limpidi folium*) and figured by de L'Obel (Adversaria 430. 1570). *S. purpurea* was figured and described by Clusius (Hist. Rar. Pl. 4 : 82. 1601) as a plant whose leaves were like the flowers of Aristolochia. He named it *Limonium peregrinum* from its fancied resemblance to sea-lavender (*Limonium carolinianum*). John Josselyn in "New England's Rarities," 1672, describes it as follows: [John Josselyn, New Eng. Rar. (ed. Tuckerman)—(95). 1865] *Hollow Leaved Lavender* is a Plant that grows in salt Marshes overgrown with Moss, with one straight stalk about the bigness of an Oat straw, better than a Cubit high, upon the top standeth one fantastical Flower, the Leaves grow close from the roots, in shape like a Tankard, hollow, tough, and always full of Water; the root is made up of many strings, growing only in the Moss, and not in the Earth, the whole Plant comes to perfection in *August* when it has Leaves, Stalks, and Flowers as red as blood, except the Flower which hath some yellow admixt."

The Indians of southern Minnesota called it ko-ko-moccasin, or owl's moccasin. From the rhizome and young leaves a concoction was made by the Canadian Indians which they believed to be a remedy for small-pox (Millspaugh, Am. Med. Pl. 19–3. 1887). This has been used to a certain extent in homeopathic pharmacy.

Linnaeus (Sp. Pl. 2d. ed. 728. 1763) adopted the name *Sarracenia* given by Tournefort (Inst. **1** : 657. 1700) in honor of Dr. Sarracin, a physician of Quebec, who sent to France the specimen described by him.

The use of the pitchers to the plant has been variously explained. Catesby (Nat. Hist. Car. **2** : 70. 1754) described them as asylums providentially provided for insects, so that they might escape from the frogs which pursue them, but most writers have thought that the advantage was on the side of the plant rather than that of the insect. Linnaeus (Sys. Veg. 491. 1784) described the evolution of the pitchered leaf and its value to the plant thus : " Sic metamorphosis folii Nymphaeae in folium Sarraceniae, ut ipsa aquam pluvialem excipiens et retinens extra aquas crescat; mira naturae providentia ! "

Wheeler (Bull. Am. Mus. Nat. Hist. **22** : 415. 1906) records the use of pitchers of *Sarracenia* as nesting places for two species of ants (*Dolichoderus Mariae* and *Tapinoma sessile*), which had not apparently suffered from their surroundings. In the same article he speaks of finding nests of a bog-loving species (*Cremogaster lineolata pilosa*) in old pitchers, the proximity of which to the functional, water-containing pitchers had caused many of the workers to drown in their ascidia. Certain carrion flies are reported to lay their eggs in the debris in the bottom of the pitchers, and the larva of one kind of mosquito is said to develop in them, living in them through the winter.

The color of the old pitchers is usually a dark purplish red, but the young pitchers are light green with a network of red veins if they grow in the open, while shade makes them develop a uniform deep green. This is illustrated in the swamps along the railroad near Lakewood, N. J., where the red of the pitchers in the clearing contrasts with the green of those growing under the cedars (*Juniperus virginiana*). Gies (Jour. N. Y. Bot. Garden **4** : 37. 1903) states that the dilute neutral extract of the leaves of *S. purpurea* is practically colorless, an acid extract is crimson, and an alkaline solution, green. He has given the name alkaverdin to the pigment, because of the beautiful green color produced by the addition of an alkali. It has a superficial resemblance to the coloring matter of the elderberry and red cabbage, but is unlike them in fundamental chemical characters. The aqueous extract is dextrorotary, reducing, and fermentable. Husemann (Pflanzenstoffe 107. 1871) describes an alkaloid called sarracin in the form of needle-like crystals which can be isolated from the rootstock.

Schimper, in 1882 (Bot. Zeit. **40**: 226. 1882) made digestion experiments upon plants of *S. purpurea* which were growing wild in the Massachusetts bogs. Some of his observations were made upon insects caught by the plants, and some upon pieces of meat that had been placed upon the leaves. He found that on closing the pitcher with tissue paper at the time of opening and thus preventing the free entrance of bacteria the digestion took place no more quickly than in water outside the plant.

Goebel's (*l. c.* 167) experiments were conducted upon plants under cultivation. The pitchers were filled to within 10 cm. of the top, and closed with a cork covered with paraffin. The height of the fluid was measured by a strip of paper fastened on the outside of the pitcher. After 48 hours the following observations were made : The fluid in the pitcher containing 1.0 per cent. formic acid in which fibrin previously swollen had been placed, was lowered 6.8 cm.; the remaining liquid was acid, the fibrin was not attacked. Water in another pitcher was reduced from 10 cm. to 8 cm. by absorption. Meat-extract neutralized with sodium hydroxide was reduced from 10 cm. to 7.5 cm. The meat-extract was full of bacteria, turbid, and alkaline in reaction. A piece of meat the size of a pea was placed with water to a height of 10 cm. in a young green pitcher. After 2 days the column was reduced to 8.2 cm., but the meat had scarcely changed though it was covered with bacteria. A small piece of meat was placed in another young pitcher with meat-extract. After 3 days the meat had a bad odor, but not as unpleasant as that of the control, and it eliminated ammonia.

From the results of these experiments Goebel concluded that *Sarracenia* had no protein dissolving enzyme or antiseptic substance and that the inner surface of the pitcher, especially the lower part, could absorb water and dissolved substances.

Experiments

The present series of experiments was undertaken under the direction of Professor William J. Gies, at the New York Botanical Garden, in the summer and autumn of 1907, in order to determine especially the digestive power of *Sarracenia purpurea* on carbohydrates, fats, and proteins.

The plants were obtained from the sphagnum bogs near Lakewood, N. J., and from a similar locality near Poughkeepsie, N. Y. No difference was observed in the behavior of the plants from the two localities. They were planted in sphagnum and kept in the propagating houses of the New York Botanical Garden under as nearly natural conditions of temperature and moisture as possible. Before a solution was placed in a pitcher the contents were withdrawn by means of a pipette, the pitcher was thoroughly, though gently rinsed with tap-water and distilled water, and swabbed with absorbent cotton. After the solution had been placed in the pitcher, it was covered with lace net which proved effectual in preventing the entrance of insects except during the use of olive oil, which was so attractive to ants that it was necessary to set the crocks containing the plants used for those experiments in dishes containing water to keep the ants out. The materials used in the protein tests were prepared under Professor Gies's personal supervision and great care was taken in handling the others.

Tests were made of the effects of various solutions with the special purpose of providing helpful information for use in the subsequent digestive work.

I. Effects of Various Solutions

Acetic Acid.—A 0.5 per cent. solution of acetic acid was found to be injurious. Pitchers containing it began to wither above the level of the liquid within a few hours, and were dead at the end of six days.

Potassium Nitrate.—A dilute solution of potassium nitrate ($m/1024$) proved harmless, though by frequent renewals it was kept in the pitchers a period of six weeks. A 0.5 per cent. solution of potassium nitrate was not injurious. In one case perceptible growth occurred in its presence, but a 1 per cent. solution caused pitchers to wither in six days, while a 2 per cent. solution made them brown and dry in three days. Both young and matured pitchers were used for this experiment but the results were the same in either case.

Sachs's Nutrient Solution. — A nutrient solution such as that commonly used as a water culture for flowering plants (per 6,000 c.c.: $CaNO_3$, 6.0 gr.; KNO_3, 1.5 gr.; K_2HPO_4, 1.5 gr.; $MgSO_4$, 1.5 gr.; $FeSO_4$, a trace) was placed in pitchers, and caused them to begin to decay within a few days, the tissues being entirely dead in from two to three weeks.

Liebig's Meat Extract. — The effect of a stimulant was tested by means of a dilute solution of Liebig's meat extract. Bacteria and infusoria developed in great numbers, however, and the pitcher began to wither in less than a week, becoming entirely decayed in about two weeks.

Milk. — A solution of milk, one drop in 10 c.c. of distilled water, which was neutral to litmus when placed in the pitcher, gave no odor and no acid reaction with litmus at the end of six days. When the concentration was doubled the solution became acid and the pitcher decayed almost completely in two weeks. A solution of milk, 20 per cent. by volume in distilled water, coagulated and became unpleasant in odor, within two days. It was inferred that the pitcher gave out an alkaline substance which reacted with the acid produced in the very dilute solution of milk but was not sufficient to neutralize the solutions of greater strength. There was nothing to indicate that the milk fat or protein was digested.

Distilled Water. — For comparison with the preceding solutions, distilled water was kept in certain pitchers for a period of about five weeks, by means of frequent renewals. There was no change in the external appearance of the pitchers, which is interesting from the fact that a concentrated solution of sucrose was equally harmless, so that the tissue of the pitcher is able to adapt itself to solutions widely different in osmotic strength.

The following solutions were also placed in the pitchers of *Nepenthes distillatoria*, the plants being kept in the propagating houses of the New York Botanical Garden under the same conditions as those of the plants of *Sarracenia.*

Potassium Nitrate.— A dilute solution of potassium nitrate (*m*/1024) proved harmless at the end of nine days as far as could be determined from external appearances, but after twelve days the pitcher began to wither.

Sachs's Nutrient Solution. — *Nepenthes* pitchers were somewhat more resistant to the nutrient solution than those of *Sarracenia,* as the withering of tissues was not apparent until about eight days had elapsed from the time the solution was put into the pitchers.

Liebig's Meat Extract. — *Nepenthes* pitchers proved more resistant to the dilute solution of Liebig's meat extract than *Sarracenia,* as the pitcher contents did not seem foul and the pitchers did not decay during the two weeks which the solution was allowed to remain in them. This may have been due to the digestion of the bacteria by infusoria, which were present in large numbers. Of course it is possible that bacteria were digested by the proteolytic enzyme, nepenthin.

II. Effects on Carbohydrates

Glucose. — A 10 per cent. solution of glucose was placed in pitchers of *Sarracenia* and allowed to remain from four days to three weeks. With Fehling solution they gave the reddish brown coloration promptly in every case, on heating, which indicates that at least some of the glucose remained, although no tests were made to determine the absence of reducing substances that might have been produced from the glucose. The quantity of the latter was naturally diminished by ordinary fermentation. There were no indications of a detrimental influence exerted by any of the fermentation products. The α-naphthol test indicated in each case the presence of much carbohydrate.

Sucrose. — Solutions of cane sugar (sucrose, c.p.) of a very low degree of concentration (less than 1 per cent.) were introduced into the pitchers of *Sarracenia.*

There was no apparent bad effect. Further trials with stronger solutions were made until it was found that a solution of 33⅓ per cent. could be resisted for two months, with no apparent injury to the pitcher. The growth of the young pitchers containing such a solution was equal, so far as it could be measured, to that of pitchers containing water. Solutions of the various strengths were tested with hot Fehling solution after they had been in the pitchers from three to seven days. The contents of each pitcher gave a reddish precipitate of copper oxide, indicating the production of invert sugar. A heavy reduction of Fehling solution also occurred spontaneously without heating although water from the pitchers did not behave in this way.

As checks for this experiment, Fehling solution, as well as Fehling solution with an equal quantity of the stock sugar solution was boiled, but neither gave an indication of reduction.

Starch. — Starch paste was placed in the pitchers and allowed to remain three or four days, in one case as long as thirteen days, when it was removed and tested in the usual way with Fehling solution. The result indicated that a reducing compound, presumably sugar, had been formed, the exact nature of which was not determined however. When Fehling solution was added to starch paste from the pitchers *without boiling*, no reduction occurred, so that the reducing power of the contents was not so marked as in the case of the cane sugar. Tested with iodine, a few blue granules indicated that not all the starch had been hydrated. Toluol sufficient to form a thin film over the top of the fluid in the pitcher was added in some cases but the reduction was the same as in the case of pitchers to which no antiseptic had been added. From this it may be concluded that the change from starch to reducing substance (sugar ?) is due to an enzyme secreted by the cells of the pitcher. There were no indications of fermentation in the pitchers with toluolized contents.

As checks in the experiments on the action of the pitchers upon starch paste, Fehling solution was tested by boiling ; tap-water and Fehling solution were boiled together ; and tap-water which had been in the pitchers for the same length of time and under the same conditions as the starch paste, was boiled with Fehling solution ; also, tap-water to which toluol had been added, and which had been allowed to stand in the pitchers the same length of time. Samples of the fresh starch paste and of that which had been allowed to stand in a flask near the pitchers, with and without the addition of toluol, were boiled with Fehling solution. In no case was there any reduction, hence the reduction which occurred with the liquid from the pitchers cannot be attributed to impurities in the fluids used in the experiments.

The above carbohydrates were also introduced into the pitchers of *Nepenthes*, with the following results :

A solution of glucose of the same concentration as that used in the pitchers of *Sarracenia* was placed in the pitchers of *Nepenthes* and allowed to remain four days with apparently no harmful effects. The test with Fehling solution resulted positively.

A 10 per cent. solution of cane sugar which had been allowed to stand in the pitchers of *Nepenthes* four days was tested with Fehling solution but failed to manifest reducing power, hence it was inferred that no cane sugar reducing enzyme was present in the contents of the pitchers in this experiment. Probably no such enzyme is normally produced by *Nepenthes*.

Thin starch paste was placed in the pitchers of *Nepenthes* and tested after four days with Fehling solution, but no reduction occurred, which indicates that *Nepenthes* does not give out such a starch splitting enzyme as that secreted by *Sarracenia*. The iodine test showed that the starch granules in the paste had not been broken down.

As these experiments were conducted at the same time as those upon *Sarracenia*, the same checks applied to both, making the results all the more significant.

III. Effects on Fats

Olive Oil.—As a test of the fat-digesting power of *Sarracenia*, washed neutral olive oil, in the proportion of 0.4 c.c. of oil to 9.6 c.c. of distilled water or tap-water was used. The mixture was well shaken immediately before it was introduced into the pitchers. After the mixture had been in the pitcher from four to seven days it was removed and titration was effected by means of phenolphthalein as the indicator, the number of drops of *m*/100 potassium hydroxid solution needed to neutralize a uniform quantity of the fluid being taken as a measure of the lipolytic power of the liquid. The amount of alkali required (except in certain abnormal cases, which were caused by the accidental presence of ants in large numbers and consequent putrefactive lipolysis) was the same as for an identical volume of the liquid which had not been introduced into the pitchers, so it may be inferred that no digestion of the fat occurred.

As a check, a mixture of olive oil and water of the same proportion as that used in the preceding experiments, with the addition of toluol was placed in several pitchers but the amount of alkali necessary to neutralize was so nearly the same in every instance as to indicate that the oil was neutral and that no digestion occurred.

Ethyl Butyrate. — As a further test of the fat digesting power of *Sarracenia*, tap-water which had been left in the pitchers one day was removed and placed in stoppered bottles with ethyl butyrate in the proportion of four drops of the butyrate to 2 c.c. of the pitcher liquid. It was allowed to remain at room temperature twenty-four hours and then titrated, phenolphthalein being used as the indicator and the lipolytic activity of the fluid being measured by the number of drops of *m*/100 sodium hydroxide solution needed to neutralize it. In place of tap-water, a very dilute solution of potassium hydroxide (KOH *m*/100), and also a very dilute solution of acetic acid (KOH *m*/100), was used in testing the contents of certain pitchers, but the number of drops of the alkaline solution needed for neutralization did not indicate any digestion.

As a check the stock liquid which had not been in the pitcher was subjected to the same test as the pitcher contents in each case, and the results were practically the same as with the pitcher fluid.

Olive oil and water, in the same proportions as those used in the case of *Sarracenia*, were placed in the pitchers of *Nepenthes* and the titration process was conducted in the same manner, but no digestion was detected.

The experiment with ethyl butyrate was repeated with the substitution of tap-water which had been in the pitchers of *Nepenthes* instead of *Sarracenia*, one day. No digestion was indicated.

IV. Effects on Protein

Fibrin. — Water which had been left in the pitchers of *Sarracenia* six days was removed and placed in bottles to each of which a granule of fibrin was added. As checks, toluol was added to some of these, dilute acid to others, and dilute alkali to a third set, the acidity or alkalinity being in each case below the harmful point as determined by the earlier experiments. Toluol was added to a portion of the acid and alkaline mixtures. The result was quite uniform, for the fibrin granule remained apparently unchanged in each liquid.

General Conclusions

The results of the above experiments may be summarized as follows:

1. The pitchers of *Sarracenia purpurea* can adapt themselves to solutions of very different osmotic strengths.

2. They give out an enzyme which hydrates sucrose and starch to reducing materials, presumably simple sugars.

3. They have no fat-digesting power.

4. They do not secrete a protein-dissolving enzyme.

In the tests which were made upon the pitchers of *Nepenthes* the resistance to solutions of marked difference in osmotic strength was shown to be the same as in the case of *Sarracenia*. The plants differed in that *Nepenthes* did not give out into the pitcher cavity any enzyme capable of hydrating sugar and starch, whereas *Sarracenia* did. The experiments as to protein digestion in *Nepenthes* were inconclusive, but they were not repeated partly because of insufficient material and partly because the demonstration of the existence of a protein-dissolving enzyme in *Nepenthes* by Vines (Ann. Bot. **12** : 545. 1898) was accepted as final.

Sarracenia purpurea belongs to the class of plants which, like the bromeliads of the tropics or our northern catch-fly, illustrates a mal-adaptation between plants and animals, for while they serve as traps for insects they are neither harmed nor benefited by them, unless the number be very great. In the sphagnum bogs where *Sarracenia* grows, the concentration of salts and nitrogenous matter about its roots is so great as to place them practically under xerophytic conditions. This would tend to render the root system inefficient as a means of water absorption and make the possession of a water-storing organ like the pitchered leaf of great advantage to the plant.

The epiphyte *Nepenthes* represents the highest degree of adaptation, in that it produces a protein-dissolving enzyme, the nepenthin of Vines (Ann. Bot. **15**: 563. 1901). Even here, however, the absorption of protein by the leaves is not absolutely essential to the life of the plant, though of great advantage. *Nepenthes*, then, stands at the upper limit in the evolution of plants with pitchered leaves, while *Sarracenia purpurea* is near the lower limit. Between them are numerous forms with varying degrees of adaptation.

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SPECIES AND VARIETIES

By T. D. A. Cockerell

The recent discussions on the species question, particularly that of the Botanical Society, printed in the May number of the American Naturalist, show at least one thing — that the matter may be regarded from very diverse points of view. This being so evident I beg permission to add yet another to the already numerous collection.

Politically, I am an American; but biologically, an Englishman, with many of the idiosyncrasies of that singular race. According to current report, one of the peculiarities of the English is a limited sense of humor. I rather incline to the opinion that this is not wholly to their discredit; but nevertheless, I am far from proposing legislation to prohibit anyone from making a joke unintelligible to the Anglo-Saxon mind. Such restrictions have probably never been contemplated in respect to jokes, but are they not a little like those desired by botanists, who insist that all species must be discernible to general students of plants? Such persons talk about the *creation* of species by botanists, showing thereby, and in other ways, their opinion that species are purely artificial things. Their attitude toward species is something like